Orbital Platform Acoustic Surveillance via Luminance Oscillation Analysis

11 May 2025
Simon Edwards
Research Acceleration Initiative

Introduction

LASER-enabled microphones provide and impressive capability to capture acoustic information from a distance and have been demonstrated effective throughout many decades of use. Limitations of LASER-enabled microphones include the potential for the LASERs to be detected by a sophisticated adversary, limited effectiveness in the absence of appropriate reflective surfaces which may be used to enable the necessary interferometric function and the requirement for substantial amounts of power, much of which is consumed by gyroscopic stabilizers.

In the common situation in which two individuals are conversing while walking in the open, it is remarkably difficult to capture acoustic information from a distance and solutions are therefore desired along these lines.

Abstract

Sensitive photodetectors are generally relied upon to capture images in conditions of low light, but may have an alternative application for use in acoustic information inference under standard lighting conditions. Without the need for active emission of light, ambient light may be used to infer acoustic information from a distance provided a sufficiently sensitive photodetector capable of measuring subtle differences in the intensity of captured light over time timescales of hundredths of a second (i.e. those associated with the rate of oscillation of sound waves associated with the human voice.)

Light, when traveling through an atmospheric medium devoid of sound, could be expected to scatter by a given amount. This scattering is most obvious over longer timescales and is observable to the human eye in the case of mirages caused by hot air rising up from hot pavement, for example, and can be seen in the twinkling of stars. That same “twinkling” effect could be expected to be produced by sound waves in a localized area whereas the oscillation is too subtle to be seen by the human eye. When sound waves are introduced to the atmosphere, areas of increased density are created which scatter light to a greater degree than would air of mean density. Although areas of decreased density are necessarily generated by the sound waves and although the total volume of atmosphere remains unchanged, atmosphere featuring striations of increased density will produce a greater optical scattering effect than air of uniform density i.e. a section of atmosphere devoid of sound waves.

Thus, we can deduce from this that the presence of a sound wave will have the net effect of reducing the intensity of detected light over the relevant timescale and that the louder the sound and the closer it is to the observed

area, the more intense the scattering and therefore the light-scattering effects.

However, it is difficult to extract information concerning acoustic energy by looking for depressions in the intensity of captured light associated with direct line-of-sight. We might be able to infer acoustic information in this manner, but only by using multiple detectors, having precise information concerning range (which would, in and of itself, require the use of LASERs) and which would also demand a stationary target.

Using a single photodetector, it may, however, be practically possible to infer acoustic information by watching for zones of *increased* brightness migrating across the field of view associated with the transverse travel of sound (not toward, but at a 90-degree offset relative to the photodetector.) The ability to watch from a side-angle would allow for the relative sequence of the emission of the sound waves to be clearly seen whereas looking at these waves head-on would make it impractical to determine which interference was being caused by which of millions of scattering layers.

From the side-angle, zones of increased brightness should be visible which fall within the sensitivity of our most modern photodetectors. These would, with sufficient contrast enhancement, visually resemble ripples moving from one side of the image to the other. Ambient light from multiple directions would tend to be channeled into these ripples or striations of increased atmospheric density. The increase in brightness associated with this light-channeling effect would exceed the light-diminishing effects of the same light passing through the ripples at a near-transverse angle.

In order to observe these ripples, one would require a photodetector capable of observing changes in relative brightness over scales of distance associated with individual sound waves. A woman’s voice, for example, has a wavelength of 1.6 meters, which would make the aforementioned fluctuations in brightness easily distinguishable in terms of spatial resolution. The key to taking this kind of measurement is the ability to measure the subtle changes in brightness associated with this sort of acoustic energy. This requires the ability to detect subtle oscillations in brightness and the ability to filter out fluctuations associated with other effects such as thermal variations. This process would be relatively straightforward. The difference in brightness detected could be predicted to be about two or three hundred additional photons emanating from a spatial area which would ordinarily feature one million times as many photons.

Conclusion

It would have as a disadvantage that it would not function appropriately at night without an artificial light source and would not be able eavesdrop in indoor venues. However, its functional range and resistance to acoustic interference would exceed that of parabolic microphones and power consumption would be lesser than that of LASER-enabled microphones.

Because orbital platforms feature resolutions more granular than one meter, this proposal opens up the exciting possibility of being able to carry out acoustic surveillance tasks from orbital platforms during daytime hours.